

## **DISPLAY FORM HAVING MAGNETICALLY ATTACHABLE PARTS**

### **CROSS-REFERENCE TO RELATED APPLICATIONS**

This application is a continuation-in-part of U.S. application no. 09/771,431, filed January 26, 2001, which claims priority from U.S. provisional application no. 60/178,187, filed January 26, 2000, both of which are incorporated herein by reference to the extent not inconsistent herewith.

### **BACKGROUND**

Forms or manikins to display clothing or other merchandise are models of complete human bodies or parts thereof, often of life-size proportions. It is difficult to dress such forms unless the limbs are detachable.

U.S. Patent 3,028,058 discloses a manikin with truncated legs, swiveling arms, and a detachable head. In manikins with removable parts, at least one leg is often made to be removable, arms are removable, and the torso may be made in two parts. Hands may also be detachable. Bayonet attachments are common means for attaching detachable limbs to forms, wherein a projection on the limb must be inserted into an appropriately shaped hole in the form, and turned for locking into place. U.S. Patent 2,595,485 describes a fastener of this type, as does U.S. Patent 2,081,071. There are numerous drawbacks to this method. The operation of attaching the removable piece must usually be performed blind, i.e. under the clothing. Often, once the removable piece is locked into position, it cannot be changed so as to place the limbs in various expressive attitudes. Further, if the limb is bumped, it may be easily broken, or the entire form knocked over and damaged.

One attempt to solve these problems is described in U.S. Patent 5,727,717, which provides joints for manikins which use sandwich magnets to keep the limbs in place. Male and female contours are used to provide mating surfaces, and once the joint is in place, it does not rotate. A drawback of this device is that the sandwich magnets do not provide sufficient depth-of-pull to keep the limb from being easily knocked off by customers and store personnel by bumping when the form is in use. If the limb is bumped with sufficient force to

overcome the on-contact strength of the magnet, the limb will simply fall off. Further, the limb must be positioned with greater accuracy for attachment, since the sandwich magnet does not exert much force at a distance therefrom to pull the limb into place when it has been placed approximately in the correct position. This device may allow limbs to be positioned in two positions 180 degrees apart, but does not allow for positioning in attitudes between these extremes. Moreover, it is difficult to provide sufficient strength with the sandwich magnets described in that patent for secure attachment at small joints such as wrists and ankles, and the weight to strength ratio of such sandwich magnets is not good.

A lightweight means for attaching removable limbs to a form is needed which allows the limbs to be easily seated into place when the operator moves them into approximate alignment, which holds with sufficient force that the limbs are not easily knocked off by being bumped, but which does allow for detachment of the limbs when sufficient force is applied which would otherwise knock over and damage the entire form.

All publications referred to herein are incorporated by reference to the extent not inconsistent herewith.

## SUMMARY OF THE INVENTION

A form is provided which has a removable piece attached thereto by a magnetic system comprising a magnetic assembly having a depth-of-pull sufficient to cause the removable piece to seek home, i.e., begin to move toward the attracted material, at a distance of at least one inch or, in other embodiments, a distance greater than one-half inch, e.g., a distance of about three-fourths inches. In one embodiment, this depth of pull is about 120 gauss at one inch, more preferably it is greater than about 200 gauss at one inch and, most preferably, is about 240 gauss at one inch. Said magnetic assembly is positioned on said form or said removable piece. Said magnetic system also comprises an attracted material on the other of said form or said removable piece so as to mate with said magnetic assembly.

A "form" is a manikin which may be in the shape of a human or animal, or a stylized human or animal. The removable piece may be any portion of the form, and is preferably

selected from the group consisting of an arm, an upper arm, a lower arm, a hand, a leg, an upper leg, a lower leg, a foot, a head, a torso, and a pelvis.

The attracted material may be steel, iron, or other magnetically-adherent material known to the art, and is positioned on the other of the removable piece or the main body of the form and designed to mate with a corresponding magnetic assembly. Magnetic assemblies and attracted materials may also be placed on either or both ends of magnetic limbs, so that portions of limbs may be attached to each other, e.g. hands to lower arms to upper arms. A given detachable piece may comprise one or more structures made of attracted material, one or more magnetic assemblies, one of each, or any combination thereof as required to assemble the complete form.

The attracted material is preferably a piece of metal, preferably a steel disc having a thickness of at least about one-eighth inch. A thinner material will result in a less strong magnetic bond. Thicker pieces may be used, but will result in a heavier and more costly joint.

The depth-of-pull of the magnetic assembly is the amount of force exerted by the magnetic material at a point a given distance from the magnetic assembly. In different embodiments, the magnetic assembly has a depth of pull of at least about 160 gauss or at least about 170 gauss at a distance of one inch. Preferably, the magnetic assembly has a depth-of-pull of at least about 200 gauss at one inch, and more preferably a depth-of-pull of about 240 gauss at one inch. The depth-of-pull is preferably no greater than about 250 gauss at one inch to avoid pinching the operator's fingers by having the magnetic assembly engage with the attached material too quickly and strongly.

In addition to its depth-of-pull, the magnetic assembly will also have an on-contact strength, which is the amount of force required to separate the magnetic assembly from direct contact with the attracted material. Preferably, for joining an adult-size arm to a form, the magnetic assembly has an on-contact strength of at least about 60-120 pounds, more preferably at least about 85 pounds, and most preferably, at least about 100 pounds. The on-

contact strength is preferably no greater than about 120 pounds. Preferably, for joining a child size arm to a form, the magnetic assembly has an on-contact strength of at least about 20-60 pounds, more preferably at least about 30 pounds, and most preferably, at least about 35 pounds. For a shoulder cap, used to cover the shoulder joint when no arm is required for the form, the on-contact strength is preferably no more than about 20 pounds. The amount of on-contact strength required should be sufficient to hold the limb in place and prevent it from easily being knocked off during normal use and not so great as to prevent manual disengagement of the limb by the operator.

Appropriate on-contact strengths will be readily ascertainable by those of skill in the art, depending on the application. A discussion of magnetic properties and design is found at [www.magnetsales.com](http://www.magnetsales.com).

While prior art magnetic limb attachments utilize magnets having good on-contact strength, the need for good depth-of-pull has not previously been recognized, and devices which provide good depth-of-pull have not been provided.

As used herein, depth-of-pull is defined in terms of gauss readings at various distances from the magnetic material measured in air, in the absence of an attracted material.

A greater or lesser amount of magnetic material may be used in a larger or smaller magnetic assembly designed to fit infant wrist joints, adult arms, legs, heads, or other parts with differently-sized cross-sections to provide the required depth-of-pull. Preferably, the magnetic assembly is arranged as described herein for the preferred embodiment, scaled up or down as appropriate. However, other materials and configurations may be used, as will be appreciated by those skilled in the art.

The cup design is especially useful for adapting to various joint sizes since its on-contact strength can be varied, e.g., from around 0.5 pounds up to 180 pounds with selection of appropriate magnetic materials.

The magnetic material and configuration of the magnetic assembly to provide appropriate on-contact strengths will be readily ascertainable by those skilled in the art without undue experimentation in accordance with principles discussed herein and known to the art.

The manikins of this invention having magnetically attachable parts have the following advantages: If the manikin is knocked over, or if someone pulls on the attached part, it will come loose rather than breaking off; and the mating parts are self-seeking in use, so that they will come together in proper orientation even when being mated beneath clothes. Generally, manikins are dressed with arms removed, and the arms then have to be inserted and positioned inside the sleeves "blind," without the dresser being able to see to align them properly. The self-seeking feature of the magnetic mating parts of this invention substantially aids in ease of dressing and provides significant time savings for manikin dressers.

In a preferred embodiment hereof, a cup magnetic assembly comprising a circular cup which serves as a pole piece is provided. It is believed that the cup shape focuses the magnetic energy toward the front (top edge of the cup), minimizing leakage of magnetic force. The cup need not be circular; it can also be square, rectangular, oval, polygonal, or other shapes. A magnetic material within the cup provides the magnetic force. Many magnetic materials are known to the art including strontium ferrite ceramic magnets, neodymium and samarium cobalt. To optimize performance and cost, combinations of known magnetic materials may be used, e.g., combinations of lower power magnets such as strontium ferrite ceramic, ferrite with higher power magnets such as neodymium or strontium cobalt, or either type with arnico or other medium power magnet.

The cup assembly allows the magnetic field to be forced to the outer edges of the cup to take full advantage of the magnets being used.

A magnet seated within the cup, such as a ring magnet e.g. a ceramic magnet such as a strontium ferrite ring having relatively less depth-of-pull, preferably not in contact with the sides of the cup, may be used to provide on-contact strength for the magnet. As will be

apparent to those skilled in the art, other types of magnetic materials, or combinations thereof, may also be used. The shape of the magnetic material may be varied; however, the magnetic material should not extend to the top of the cup, since if it is in direct contact with the attracted material, either some of the magnetic force will be lost or the on-contact strength could be increased to unacceptable levels, depending on orientation of the poles of the magnetic material. Alternately, a non-magnetically adherent material can be used to prevent direct contact between the magnetic material and the attracted material (e.g. an austenitic stainless steel lid placed on the magnetic assembly to cover the magnets), in which case the magnetic material need not be below the top of the cup. In an embodiment where the magnetic material does not extend to the top of the cup involving a cup-shaped pole piece having a diameter of two and a half inches and a height of one-half inch, there is a gap of about 0.15 inch between the magnetic material and the top of the cup.

In order to provide more depth-of-pull, additional magnetic material having a strong depth-of-pull in contact with the ring magnet, but separated from direct contact with the pole piece (outer edges of the cup) may be provided. Because the size of the manikin joint is limited, the size of the magnetic assembly will be limited, and it will usually be necessary to conserve space within the cup-shaped pole piece. Using nothing but strontium ferrite ceramic magnets in the preferred embodiment of this invention might require a pole piece too large to fit within the typical manikin joint. Thus, additional magnetic materials to provide depth-of-pull are preferably made of materials which provide greater depth-of-pull than the ceramic magnets. Neodymium magnets are preferred, e.g., neodymium-iron-boron materials. They may be in the form of a ring, radial arc segments, or any other desirable shape, so long as the separation from the sides of the pole piece is maintained and the desired depth-of-pull is achieved. In a preferred embodiment, the magnetic assembly comprises as additional magnetic material-- two neodymium arc segments symmetrically placed opposite each other, and spanning about 45-90 degrees of arc in the ring magnet. The size of such additional magnetic materials is selected to provide the required depth-of-pull as will be evident to those of skill in the art, or easily ascertainable without undue experimentation using the information provided herein. The additional magnetic materials are spaced apart from the pole piece (outer edges of the cup) a sufficient distance so that the magnetic force therefrom is not

substantially conducted through the pole piece. Preferably, the additional magnetic materials are spaced apart from the pole piece at least about one-eighth inch in the preferred embodiment hereof which involves the use of a circular cup-shaped pole piece having a height of one-half inch and a diameter of two and a half inches.

As will be readily apparent to those skilled in the art, the less expensive ceramic material can be entirely replaced with stronger magnetic material, and the size of the cup could be reduced accordingly; however, using a proportion of each type of material optimizes cost.

To facilitate embedding of the magnetic assembly, it preferably comprises a flange attached thereto by welding or other means known to the art which is covered by the material of the form as it is being molded or otherwise fabricated, leaving the remainder of the magnetic assembly uncovered. The flange may comprise one or more pieces of metal or other material welded to the bottom of the cup assembly so that it extends on both sides, or single pieces of metal or other material attached to the bottom of the cup so as to extend out on at least one side.

The top of the magnetic assembly preferably defines a plane, and the attracted material preferably presents a planar surface for mating with the magnetic assembly. A lid of metal, plastic or any other sheet-like material may be used to cover the magnetic assembly. If the lid contacts both the cup pole piece and a magnet within the cup, the lid should not be made of a magnetically adherent material. Non-magnetically adherent materials suitable for lids include nonmagnetic steels, where a nonmagnetic steel is a steel which is not attracted by a permanent magnet. Nonmagnetic steels include austenitic stainless steels. Other non-magnetically adherent materials suitable for use as lids include aluminum, Mylar, plastics, glass, ceramics, and other materials as known to those skilled in the art.

Preferably, the attracted material is in the form of a disc (circular or rounded plate) of steel or other magnetically attracted material. In an embodiment, the attracted material is in the form of an oval disc. The attracted material may also have flanges or other projections therefrom for embedding in the material of the form.

The planar surfaces of the attracted material and top of the magnetic assembly contact each other. Each of the magnetic assembly and attracted material may be equipped with a mating pin or pins and an optional indexing pin or pins, which mate with corresponding holes in the other of the attracted material or magnetic assembly. In an embodiment, the mating pin is centrally located, extending upward from the bottom of the cup magnet. Preferably it is rounded or chamfered to provide ease of seating in the corresponding mating hole when it comes into contact with an edge thereof. The index pin or pins may be similarly rounded or chamfered. A plurality of index holes may be provided so that the removable limb can be placed in different positions, e.g. an arm can be extended downward, outward or upward, a hand can be cupped or turned over, and the like.

If desired, additional means can be provided to the magnetic system for providing holding force in the direction of the magnetic attraction between the magnetic assembly and the attracted material. Such additional means can include Velcro strips, adhesive strips or other materials on the planar surfaces of the components or within the holes and pins, latches, or other means known to the art.

The magnetic assemblies and attracted materials may be sized to accommodate the joints being attached. For example, smaller versions might be used at the wrists and ankles. The proportion of materials having a stronger magnetism to mass ratio could be increased to allow for a stronger magnetic bond using the smaller size.

Methods for attaching removable pieces of forms are also provided herein comprising aligning the pieces to be attached and allowing them to be held in place by magnetic force, or placing the magnetic attachment systems in approximate alignment, and allowing magnetic force to complete the mating. Approximate alignment means that the components (the magnetic assembly and attracted material) are close enough together that the strength of the magnetic field at that distance (the depth-of-pull) is sufficient to pull the parts together. Specifically, the magnetic pull should be felt when the components are placed at least about one inch apart. It is often desirable that the distance between the removable piece and the



form be greater than about one-half inch, and preferably greater than about two-thirds or three-fourths of an inch when sufficient pull is present to allow the pieces to "seek home." Greater precision than these distances is difficult to achieve when the operator is attempting to align the parts "blind," i.e. under clothing.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a form of this invention with removable and adjustable limbs. Figure 1A shows a front view and Figure 1B shows a side view.

Figure 2 shows a portion of a cup magnet magnetic assembly of this invention. Figure 2A is a top plan view, and Figure 2B is a side view.

Figure 3 shows a cup magnet magnetic assembly of this invention comprising flanges, a mating pin and an index pin. Figure 3A is a plan view and Figure 3B is a side view.

Figure 4 shows a magnetic assembly of this invention mated with an attracted material.

Figure 5 is a side view of a knee joint showing the metallic plate.

Figures 6A and 6B compare the lines of magnetic force in prior art form attachment magnet assemblies and the magnet assembly of this invention, showing how greater depth-of-pull is achieved in this invention.

Figures 7A and 7B show top and side views, respectively, of oval-shaped attracted material suitable for use with the magnetic assemblies of the invention.

Figure 8A is top view of a different cup magnetic assembly of the invention, without a centrally located mating pin. Figure 8B is a side view of the magnetic cup assembly of Figure 8A. Figures 8C and 8D, respectively show top and side views of a corresponding mating plate.

Figures 9A and 9B compare the depth-of-pull at the strongest points of attraction for the magnetic assembly of the invention and a prior art sandwich magnet.

#### DETAILED DESCRIPTION

This invention provides manikins with magnetically attachable parts. One or more limbs selected from the group consisting of whole arms, forearms, upper arms, whole legs, thighs, lower legs, feet, hands, and head, fingers, toes, and features may be magnetically attachable. Surrealistic features such as wings, chimeric animal parts, and the like may also be magnetically attachable parts of this invention. Joint caps such as shoulder caps may also be attachable. In a preferred embodiment, the whole arms are magnetically attachable.

The magnetic attachment comprises two mating portions: a material capable to adhering to a magnet, referred to herein as the "attracted material," such as steel, iron, or other magnetically-adherent material known to the art; and one or more magnets or magnetized materials, referred to herein as the "magnetic material," selected and arranged to provide a depth-of-pull sufficient for the attachable part to begin to seek home at a distance of about one inch, preferably at least about 120 gauss at one inch. This arrangement of the selected magnetic material is referred to herein as the magnetic assembly.

Magnetic materials may be selected to optimize cost and performance, as is standard in the industry. Table 1 lists several magnetic materials, comparing costs and coercive strengths.

Table 1  
Permanent Magnet Material Comparison Table

Material	Cost Index	Coercivity Hci (KOe)
Nd-Fe-B (sintered)	65%	Up to 30
Nd-Fe-B (bonded)	50%	Up to 11
Sm-Co (sintered)	100%	Up to 25
Sm-Co (bonded)	85%	Up to 10
Alnico	30%	Up to 2
Hard Ferrite	5%	Up to 3
Flexible	2%	Up to 2

Source: stanfordmagnets.com.

As will be appreciated by those of skill in the art, the placement of magnetic material with respect to pole pieces affects the flow and intensity of magnetic flux, and thus the strength of the magnetic assembly both in terms of on-contact strength and depth-of-pull. Placement of air gaps between magnetic material and pole pieces also affects performance. For example, in a cup magnetic assembly, if the ceramic or neodymium components are allowed to touch the sides of the cup, some of the lines of force will be short-circuited through the sides and not reach past the rim of the cup and thus not be able to flow into and hold the attracted material. However, magnetic material may be in contact with the sides of the cup if required to adjust the strength of the magnetic assembly.

The magnets may be fixed in desired relationship to each other and the pole piece(s) by means known to the art, e.g., adhesives.

In an embodiment, the mating parts also include at least one mating pin projecting from the face of one of the parts which fits into a hole sized to accommodate it on the other part.

One or more index pins may also project from the face of one of the parts, and fit into holes sized to accommodate them on the other part. In this way, the limb can be adjusted to display a variety of positions and postures.

Preferably the mating parts are in the form of substantially flat discs which may be equipped with flanges for embedding in the material of the form. The attracted material may be a disc having a flat face for mating, and the magnetic assembly preferably mates with this planar surface. In a preferred embodiment, the magnetic assembly comprises a cup construction made of a material such as steel, having magnets arranged therein. Preferably the magnets do not extend outward past the top of the "cup."

The mating parts are preferably round, but may be any shape, such as the cross sectional shape of the limb being attached, rectangular, ovoid, or other shapes, including shapes having mating concavities and convexities to provide sockets, or cylinders which may be nested together.

The depth-of-pull strength of the magnetic assembly is also important for allowing the pieces to be joined to easily "seek home," that is pull themselves into proper alignment when they have been approximately aligned. Exact alignment is difficult for the operator to achieve when dressing a manikin, since the parts to be joined will often be obscured by the clothing. The depth-of-pull strength should be sufficient for the parts to start moving together when they have been approximately aligned and are a distance of more than one-half inch apart, preferably a distance of one-third or more inches apart, more preferably three-fourths or more inches apart and, most preferably, at least one inch apart. The depth-of-pull should not be not so great as to cause injury to the operator, nor so little as to require that the pieces be placed in almost touching alignment, e.g. one-fourth inch apart, before they start to pull together.

Principles known to the art may be used to adjust the magnetic force, such as the thickness of the accepting material, the type of magnetic material used, and the mass of the magnetic material used.

Preferably, flanges extend outward from the mating parts so that the manikin body may be molded around them. Alternatively, the mating parts can be adhered to the manikin by any means known to the art including screws, welds, adhesives, and the like.

The manikin comprising the magnetically attachable parts is made of a material, preferably a molded polymeric material, capable of supporting the mating parts. Manikins of this invention comprising magnetically attachable parts may be replicas of normal human bodies, or may be missing one or more parts, such as head, feet, lower legs, or other parts enumerated above.

The attracted material may be on the manikin trunk or larger body part, and the magnetic material is on the smaller part to be attached, or vice versa. In one embodiment of this invention, manikins are equipped with magnetic mating parts at some or all joints normally articulable in the human body.

Figure 1A depicts a front view of a manikin of this invention equipped with mating magnetic portions. In the drawings, like reference numbers indicate like drawing elements. The attracted material is a metallic plate **12** and the magnetic assembly **14** is mated thereto. Mating portions are present between the head **10** and the neck **15**, between the torso **20** and the upper arms **22** at the shoulder joint **36**, between the upper arms **22** and the lower arms **24** at the elbow joints **26**, between the lower arms **24** and hands **30** at the wrists **28**, between the torso **20** and pelvis **40**, between the pelvis **40** and upper legs **50**, between the upper legs **50** and lower legs **60** at the knee joints **54**, and between the lower legs **60** and the feet **62** at the ankle joint **64**. A mating pin **18** and an indexing pin **16** are shown in the magnetic assembly **14** of the left shoulder.

Figure 1B shows a side view of a manikin of this invention showing a metallic plate **12** attached at the neck, at the shoulder **36**, and elbow **26**, and indicating a variety of positions for the arm attainable using indexing pins in the magnetic element (not shown) which fit into corresponding indexing holes **34** shown in metallic plate **12** at the shoulder **36**. This metallic plate **12** also shows mating hole **32**.

Figure 2A shows a magnetic assembly **14** of this invention consisting of a pole piece **70** in the form of a cup. Inside the cup is a ring magnet **72** in contact with the sides and bottom of the cup. Atop the ring magnet are two neodymium magnets **74** separated from the outer rim of the cup by space **78**. Figure 2B is a side view of the magnetic assembly of Figure 2A, showing that the ring magnet **72** underlies the neodymium magnets **74**, and indicating that the neodymium magnets do not extend to the top of the cup.

In the preferred embodiment, the cup is a steel cup having a 2.5 inch diameter weighing 114.5 g and about a .5 inch diameter hole in the center through which the mating pin extends. The ring magnet is strontium ferrite and weighs 85.58 g. Two neodymium magnets weigh 17.9 g each. A stainless steel cover plate, not shown, weighs 12.5 g, the mating pin weighs 16.4 g, the flange with the indexing pin weighs 28.0 g, and the entire assembly weighs 293 g.

Figure 3A shows the magnetic assembly equipped with flanges **76** for embedding the assembly in the material of the manikin, mating pin **18** for mating with a corresponding mating hole in the attracted material (metallic plate), and indexing pin **16** on flange **76** for mating with a corresponding indexing hole in the metallic plate. Figure 3B is a side view of the magnetic assembly **14** of Figure 3A, and shows the staked end **17** of the indexing pin **16** and staked end **19** of mating pin **18**.

Figure 4 shows the magnetic assembly **14** and metallic plate **12** attached to a cup **13** equipped with a flange **77** for embedding within the material of the manikin. The mating pin **18** and indexing pin **16** extend into the metallic plate **12** when the magnetic system is in use, through mating hole **32** and indexing hole **34** provided therein. Magnetic assembly **14** is equipped with flange **76** for embedding it within the material of the manikin. The magnetic assembly **14** comprises pole piece **70**, ring magnet **72**, neodymium magnets **74**, mating pin **18**, indexing pin **16**, and lid **75**. Mating pin **18** comprises a shoulder **21** to retain lid **75** in place.

In an embodiment, the metallic plate is included in a mating cup **13** equipped with flanges **77** to provide appropriate recesses for the mating and indexing pins. Preferably, the plate has a diameter of 3.5 inches, and a hole having a diameter of about .5 inches in the center to accommodate the mating pin. The mating plate may be embedded in the material of the form via the flanges, or it may be screwed or otherwise attached to structures molded into the form for that purpose.

Figure 5 shows a right side view of the knee joint **54** showing the metallic plate **12** in upper leg **50**, with indexing holes **34** and mating hole **32**.

Figure 6A shows an end view of a prior art sandwich magnet consisting of a ceramic magnet **82** and steel pole pieces **84**. Lines of magnetic force **86** indicate how the magnetic force runs from the magnet to the pole pieces, and across the top through the air between the pole pieces, as well as across the bottom through the material of the manikin **88**. This type of magnet design can provide good on-contact strength, but little depth-of-pull. Magnetic poles are indicated as N and S.

In contrast, Figure 6B shows a magnetic assembly **14** of this invention in which the lines of magnetic force **86** extend upward from the edge of pole piece **70** to provide a large depth-of-pull. Mating pin **18** and index pin **16** are also shown in this view. Magnetic poles are indicated as N and S.

Figures 7A and 7B show top and side views, respectively, of an embodiment of an oval-shaped plate and flange assembly suitable for use with the magnetic assemblies of the invention. The central portion **100** acts as the attracted material and as a mating plate for the magnetic assembly. Central portion **100** has side **103** connected to an outer portion **105**. When the assembly is attached to a manikin or a removable piece thereof, the central portion is elevated with respect to said outer portion. When the central portion is elevated with respect to the outer portion, the central portion projects further than the outer portion from the surface of the manikin or removable piece thereof where the joint is placed. Outer portion **105** acts as a flange which can then be embedded into the manikin or manikin piece. For

example, the outer portion **105** may be used to secure the plate to a polymeric form by covering the flange with liquid polymer during molding of the form. In addition, outer portion **105** may contain additional features to further secure the mating plate to the form. Figure 7B shows V-shaped depressions **107** made in the outer portion **105** and through-holes **109** formed in the vicinity of depressions **107**. In an embodiment, the through-holes **109** are formed where the outer portion **105** joins the side **103** of central portion **100**. Although the depressions in Figure 7B are shown as V-shaped, other shapes of depressions known to those skilled in the art may be used.

V-shaped depressions **107** can help ensure that the plate and flange assembly is correctly placed with the central portion **100** elevated with respect to outer portion **105** when the assembly is molded into a polymeric form. To perform this function, the depressions in the outer portion **105** should be formed so that the assembly does not sit stably on a flat surface when resting on depressions **107**. During molding of the relevant part of the polymeric form, the assembly can be held in place by a flat portion of a mating magnetic piece which contacts central portion **100**. The magnetic mating piece used during molding is not required to be the same as the magnetic assembly which forms the other side of the magnetic joint on the manikin. If outer portion **105** rather than the central portion **100** is inadvertently placed in contact with the flat portion of the mating magnetic piece prior to molding, the plate and flange assembly will not sit stably on the mating piece and the molding operator will be more likely to notice and correct the error.

During molding of a polymeric form, liquid polymer will flow through holes **109**, providing additional mechanical interlocking of the mating plate and the form when the liquid polymer solidifies. Preferably, the minimum dimension of holes **109** is about 1/8" or greater. Preferably, the maximum dimension of holes **109** is about 1/2" or less. Holes **109** are preferably spaced apart from each other so as to distribute the additional mechanical interlocking around the plate.

Figure 7A shows mating hole **32** and index hole **34**. Mating hole **32** is not required to be centrally located, as is shown in Figure 7A. In an embodiment where the mating magnetic



assembly is a circular cup assembly, the distance **a** shown in Figure 7A can be substantially the same as the radius of the circular cup. The outline of such a circular cup is shown by dashed lines in Figure 7A.

The oval shaped device in Figures 7A and 7B may be formed from a metal strip or coil by punching holes **32** and **34**, using a half-shear operation to create a height difference between central portion **100** and outer portion **105**, and further deforming outer portion **105** to create V-shaped depressions **107**, and separating the oval device from the strip or coil. Additional holes which partially define the oval and later aid in separation of the oval from the strip or coil can be punched at the same time as holes **32** and **34**. For plate and flange assemblies made using this process, the V-shaped depressions are preferably not placed along the center line connecting the mating and index holes to avoid deforming these holes while forming the V-shaped depressions. The V-shaped depressions can be formed deeply enough to tear holes **109** in the metal. In addition, a flattening operation can be used to restore planarity to central portion **100** after the die punching and half shear operation(s). Suitable steel coil thicknesses are between about 7 gauge and about 11 gauge. Other processes as known to those skilled in the art, including joining two plates or a plate and a larger ring to create an inner portion **100** elevated relative to outer portion **105**, may be used to create a plate and flange assembly similar to that shown in Figures 7A and 7B.

Figures 8A and 8B illustrate top and side views, respectively, of another embodiment of a magnetic assembly of the invention. The magnetic assembly shown in Figures 8A and 8B does not contain a central mating pin, but rather two mating pins **18** placed outside the cup. The pins are attached to flange **76**. Figure 8B shows the staked ends **19** of the mating pins. The cup may be fuse-welded to the flange, or joined by other means known to those skilled in the art. Figure 8C shows a top view of the corresponding mating plate **12** showing mating holes **32**. The mating plate is a flat circular disk with an attached strap **150**. The strap may be fuse-welded to the disk or joined by other means known to those skilled in the art. Figure 8D shows a side view of the mating plate, illustrating strap **150**. The attached strap can be molded into a polymeric form or a removable part thereof, thereby securing the mating plate to the form or removable part thereof. Because the magnetic assembly shown in Figures

8A-8B does not require a central mating pin, this design allows use of a smaller cup pole piece for a given magnet strength and magnetic material(s).

To make the devices of this invention, the components of the magnetic assembly may be glued or soldered or otherwise adhered. The metallic plate and magnetic assembly are then embedded in the manikin, preferably by molding the manikin around flanges or other projections thereof, however, these components may also be attached to the manikin by other means such as screws, adhesives, and the like, all as known to the art.

To use the magnetic joints of this invention, two parts are approximately aligned, and the depth-of-pull strength of the magnetic assembly then pulls the parts into place, with the mating pins and indexing pins in their corresponding holes. A plurality of indexing holes may be provided so that the limb can be placed in alternative positions.

#### EXAMPLE 1

The on-contact and depth-of-pull strengths of magnetic assemblies of this invention were tested and compared to those of conventional sandwich magnets using a gauss meter. Figures 9A and 9B show the points where the measurements were taken. Figure 9A shows the magnetic assembly of this invention with the poles labeled N (north) and S (south). The asterisk **90**, positioned about one-fourth inch from the center of the 2.5-inch-diameter magnetic assembly, indicates that the strongest depth-of-pull force was measured at this distance from the center. The circle **92** on the perimeter of the pole piece **70** indicates that the strongest on-contact force is measured at the perimeter. Figure 9B shows a sandwich magnet of the prior art. The asterisk **94** indicates where the strongest depth-of-pull forces were measured. This point also corresponds to circle **96**, the point where the strongest on-contact forces were measured. The magnet of this invention weighed .581 pounds. The sandwich magnet weighed 1.187 pounds. Results are shown in Table 2.

TABLE 2

Distance from Magnet	Neodymium Cup Assembly	Two-pole Strontium Ferrite Sandwich Assembly
Strongest contact on Pole Piece	2560 gauss	1410 gauss
Strongest Point on Magnet	4021 gauss	1410 gauss
1/32 inch	3850 gauss	1090 gauss
1/8 inch	2880 gauss	790 gauss
1/4 inch	1890 gauss	510 gauss
1/2 inch	850 gauss	270 gauss
3/4 inch	380 gauss	160 gauss
1 inch	240 gauss	110 gauss

These results show the superior depth-of-pull provided by the present invention. At 1/8 inch from the magnet, the force of the sandwich magnet begins to drop off drastically, despite the fact that the sandwich magnet weighs nearly twice as much as the magnetic assembly of this invention.

#### EXAMPLE 2

The on-contact and depth of pull strengths of a magnetic assembly as shown in Figures 8A and 8B were measured using a gauss meter, and are shown in Table 3. The strongest point on the magnet was measured at 3/32" ( $\pm$  about 1/32") from the center of the magnet. The depth-of-pull forces were measured at this same location. This magnetic assembly began to "seek home" at a distance of about 3/4 ." The weight of the magnet was about 0.03 lb.

TABLE 3

Distance from Magnet	Neodymium Cup Assembly
Strongest contact on Pole Piece	1500 gauss
Strongest Point on Magnet	2990 gauss
1/32 inch	2800 gauss
1/8 inch	2000 gauss
1/4 inch	1550 gauss
1/2 inch	680 gauss
3/4 inch	338 gauss
1 inch	178 gauss

Although this invention has been illustrated using various specific components, it will be appreciated by those skilled in the art that alternative constructions and methods can be substituted for those described, and are equivalent thereto.